

What is claimed is:

1. A method of authenticating registration reply messages received by a PCF that are purportedly responsive to registration messages previously sent by the PCF to a PDSN, said method comprising:

10 determining a verification threshold for validating time stamps in registration reply messages;

generating a sequence of message numbers for sequential use in a series of successive registration messages sent by said PCF to said PDSN, said sequence of message numbers having a repeat interval greater than said verification threshold;

15 inserting said sequential message numbers into successive registration messages sent by said PCF to said PDSN;

receiving a registration reply message at said PCF presumptively sent by said PDSN in response to a registration message previously sent by said PCF, said registration reply message containing a time stamp and a message number;

20 validating said message number in said registration reply message by comparing said message number in said registration reply message to the message number in a corresponding registration message sent by said PCF;

25 if said message number is valid, validating said time stamp in the said registration reply.

5       2.     The method of claim 1 wherein validating said time stamp in said registration  
reply message comprises computing an age of said registration reply message based on  
said time stamp in said registration reply message and accepting said registration reply  
message if said age is less than a verification threshold.

10      3.     The method of claim 2 wherein computing the age of said registration reply  
message comprises computing a time difference between said time stamp in said  
registration reply message and a time reference.

15      4.     The method of claim 2 wherein computing the age of said registration reply  
message comprises computing a time difference between said time stamp in said  
registration reply message and a time stamp in a corresponding registration message.

20      5.     The method of claim 1 wherein validating said time stamp in said registration  
reply message comprises:

comparing said time stamp in said registration reply message to the time stamps  
in one or more registration messages sent by said PCF;  
accepting said registration reply message if said time stamp in said registration  
reply message equals the time stamp in a corresponding registration  
message;

25      if said time stamp in said registration reply message does not equal the time  
stamp in said corresponding registration message, computing an age of  
said registration reply message based on said time stamp in said  
registration message;

accepting said registration reply message if said age of said registration reply  
message is less than a verification threshold.

6. The method of claim 5 wherein computing an age of said registration reply message based on said time stamp in said registration reply message is performed conditionally only if:

    said registration reply message contains a predetermined code; and

10     said time stamp in said registration reply message does not equal said time stamp in said registration message; and

wherein said registration reply message is rejected if said predetermined code is not present and said time stamp in said registration reply message does not match said time stamp in said registration message.

7. The method of claim 1 further comprising maintaining a time reference in said PCF.

8. The method of claim 7 further comprising synchronizing said time reference to a 20 time clock located at said PDSN.

9. The method of claim 8 wherein synchronizing said time reference to a time clock located at said PDSN comprises determining a difference between said time reference and said PDSN time clock.

10. The method of claim 8 wherein validating said time stamp in said registration reply message comprises computing an age of said registration reply message based on said time stamp in said registration reply message and accepting said registration reply message if said age is less than a verification threshold.

11. The method of claim 10 wherein computing the age of said registration reply message comprises computing a time difference between said time stamp in said registration reply message and a time stamp in a corresponding registration message.

10 12. The method of claim 10 wherein computing the age of said registration reply message comprises computing a time difference between said time stamp in said registration reply message and said time reference.

15 13. The method of claim 1 wherein generating a sequence of message numbers comprises incrementing said message number in each successive registration message sent by said PCF to said PDSN.

20 14. The method of claim 13 wherein incrementing said message number in each successive registration message sent by said PCF to said PDSN comprises adding a random number to a previous message number.

15. The method of claim 13 wherein said sequence of message numbers increases monotonically.

5        16. A method of authenticating a second registration message received by a PCF  
that is purportedly responsive to a first registration message previously sent by the PCF  
to the PDSN, said method comprising:

            inserting a message number into said first registration message;  
            sending said first registration message from said PCF to said PDSN  
10        receiving said second registration message at said PCF, said second registration  
            message containing a time stamp and a message number;  
            authenticating said second registration message based on said message number  
            and said time stamp contained in said first registration message;  
            accepting said second registration message if said second registration message  
15        contains a valid message number and a valid time stamp.

17. The method of claim 16 wherein authenticating said second registration message  
based on said message number and said time stamp comprises:

            validating said message number in said second registration message; and  
20        if said message number is valid, validating said time stamp in said second  
            registration message.

18. The method of claim 17 wherein validating said time stamp in said second  
registration message comprises computing the age of said second registration message  
25        based on said time stamp in said second registration message and comparing said age  
            to a verification threshold.

19. The method of claim 18 wherein computing the age of said second registration  
message comprises computing a time difference between said time stamp in said  
30        second registration message and a time reference.

20. The method of claim 19 wherein computing the age of said second registration message comprises computing a time difference between said time stamp in said second registration message and a time stamp in said first registration message.

10 21. The method of claim 16 wherein validating said time stamp in said second registration message comprises:

comparing said time stamp in said second registration message to said time stamp in said first registration message;

accepting said second registration message if said time stamp in said second registration message equals said time stamp in said first registration message;

if said time stamp in said second registration message does not equal said time stamp in said first registration message, computing an age of said second registration message based on said time stamp in said first registration message; and

accepting said second registration message if said age of said second registration message is less than a verification threshold.

22. The method of claim 21 wherein computing an age of said second registration message based on said time stamp in said second registration message is performed conditionally only if:

said second registration message contains a predetermined code; and

said time stamp in said second registration message does not equal said time stamp in said first registration message; and

5 wherein said second registration message is rejected if said predetermined code is not present and said time stamp in said second registration message does not match said time stamp in said first registration message.

23. The method of claim 16 further comprising maintaining a time reference in said  
10 PCF.

24. The method of claim 23 further comprising synchronizing said time reference to a time clock located at said PDSN.

15 25. The method of claim 24 wherein synchronizing said time reference to a time clock located at said PDSN comprises determining a difference between said time reference and said PDSN time clock.

20 26. The method of claim 24 wherein validating said time stamp in said second registration message comprises computing the age of said second registration message and comparing said age to a verification threshold.

25 27. The method of claim 26 wherein computing the age of said second registration message comprises computing a time difference between said time stamp in said second registration message and said time reference.

28. The method of claim 24 further comprising generating a time stamp for said first registration message sent by said PCF to said PDSN based on said time reference.

5 29. The method of claim 28 wherein computing the age of said second registration  
message comprises computing a time difference between said time stamp in said  
second registration message and said time stamp in said first registration message.

5       30.     A method of guarding against erroneous re-synchronization of a first reference time used by a packet control function (PCF) to time-stamp messages sent to a packet data serving node (PDSN) with a second reference time used by said PDSN in validating said messages sent by said PCF, the method comprising:

receiving a message presumptively from said PDSN at said PCF indicating that

10           said first reference time requires re-synchronization with said second reference time, said message containing a PDSN time value;

comparing said PDSN time value with said first reference time to determine a time difference; and

adjusting said first reference time based on said PDSN time value if said time difference does not exceed a pre-determined time threshold.

15       31.     The method of claim 30 wherein receiving a message presumptively from said PDSN at said PCF indicating that said first reference time requires re-synchronization with said second reference time comprises receiving a registration reply message 20 purportedly responsive to a registration message previously sent by said PCF to said PDSN.

25       32.     The method of claim 31 wherein said registration message includes an identifier, comprising a PCF time stamp and a message number, and further comprising verifying that said registration reply message contains a matching message number.

30       33.     The method of claim 32 wherein said message number in said registration message is part of sequence of message numbers with a repeat interval greater than said pre-determined time threshold.

5    34. The method of claim 30 further comprising:  
      maintaining a base PCF time at said PCF; and  
      determining said first reference time at said PCF by adjusting a copy of said base  
      PCF time in accordance with said PDSN time value.

10    35. The method of claim 34 further comprising synchronizing said base PCF time  
      with a network-based time.

5       36. A PCF for routing packets between a PDSN and a BSC, said PCF comprising:

          a signaling component that sends a registration request to said PDSN and

          receives a registration reply from the PDSN;

          wherein said registration request comprises an identification element including a

          message number;

10      wherein said registration reply comprises an identification element including a

          time identifier and a message number; and

          wherein said signaling component authenticates said registration reply based on

          said message number and said time identifier returned by said PDSN in

          said registration reply.

15      37. The PCF of claim 36 wherein said signaling component validates said message

          number in said registration reply by comparing said message number in said registration

          reply to said message number in said registration request.

20      38. The PCF of claim 36 of claim 37 wherein said signaling component validates said

          time identifier in said registration reply by computing a differential time value between

          said the PCF's current time and the time identifier in said registration reply and

          comparing said differential time value to a threshold time value.

25      39. The PCF of claim 38 wherein said registration message sent by said PCF to said

          PDSN further includes a time identifier, and wherein said signaling component validates

          said time identifier in said registration reply by computing a differential time value

5 between said time identifier in said registration reply and said time identifier in said registration request and comparing said differential time value to a threshold time value.

40. The PCF of claim 36 wherein said PCF synchronizes its time clock with the PDSN's time clock when the message number in said registration reply is identical to the  
10 message number in said registration request and a differential time value between said time identifier in said registration request and a time reference is less than a threshold time value.

41. A wireless communication network comprising:  
15 a base station controller (BSC);  
a packet data serving node (PDSN);  
a packet control function for routing data between said BSC and said PDSN;  
wherein said PCF includes a signaling component that sends a registration  
request to said PDSN and receives a registration reply from the PDSN,  
20 said registration request comprising an identification element including a message number, said registration reply comprising an identification element including a time identifier and a message number; and  
wherein said signaling component authenticates said registration reply based on  
said message number and said time identifier returned by said PDSN in  
25 said registration reply.

5       42. The wireless communication network of claim 41 wherein said signaling component validates said message number in said registration reply by comparing said message number in said registration reply to said message number in said registration request.

10      43. The wireless communication network of claim 42 wherein said signaling component validates said time identifier in said registration reply by computing a differential time value between said the PCF's current time and the time identifier in said registration reply and comparing said differential time value to a threshold time value.

15      44. The wireless communication network of claim 43 wherein said registration message sent by said PCF to said PDSN further includes a time identifier, and wherein said signaling component validates said time identifier in said registration reply by computing a differential time value between said time identifier in said registration reply and said time identifier in said registration request and comparing said differential time value to a threshold time value.

20      45. The wireless communication network of claim 41 wherein said PCF synchronizes its time clock with the PDSN's time clock when the message number in said registration reply is identical to the message number in said registration request and a differential time value between said time identifier in said registration request and a time reference is less than a threshold time value.